Existing Arctic observing capacity assessed in the framework of INTAROS

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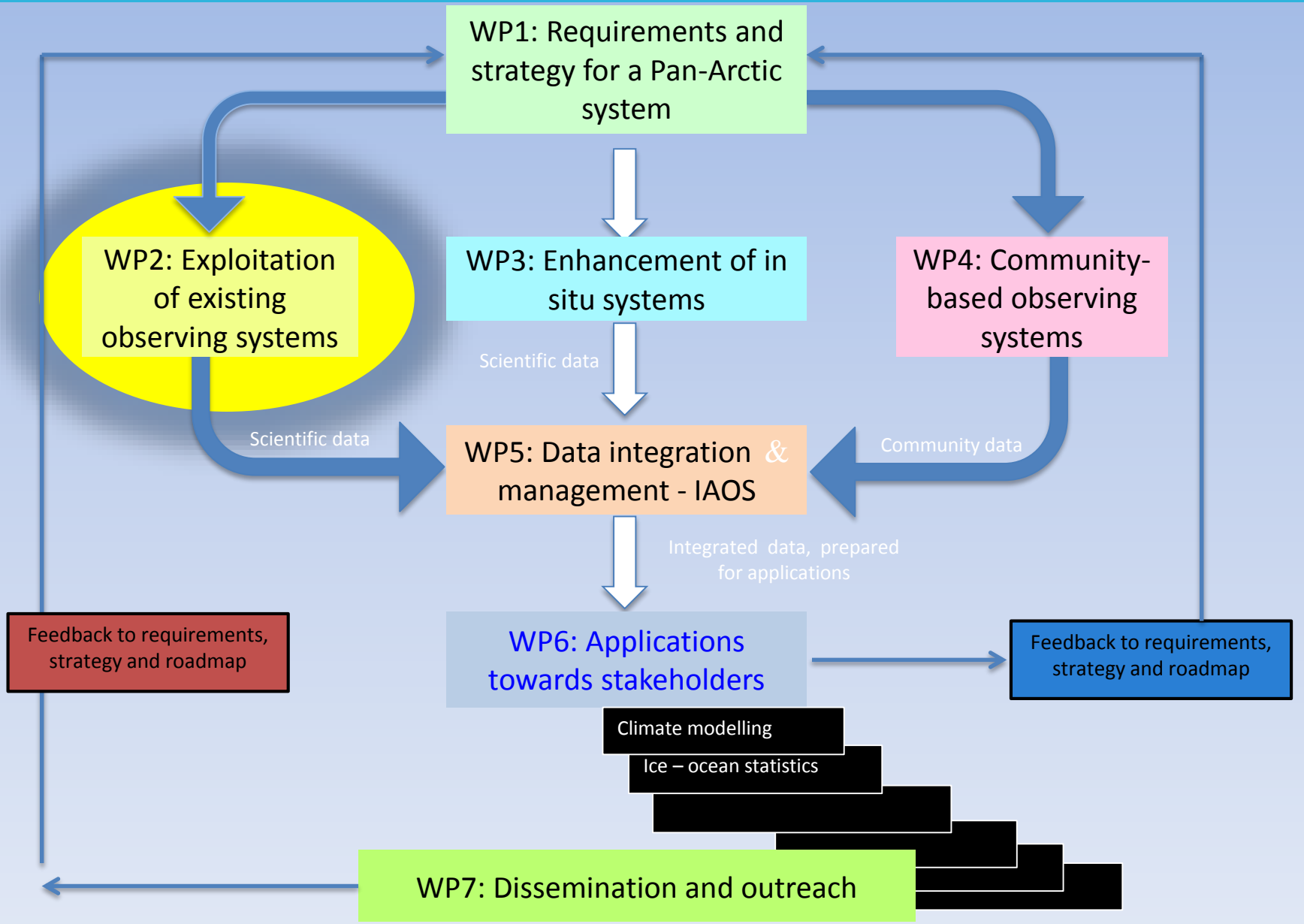
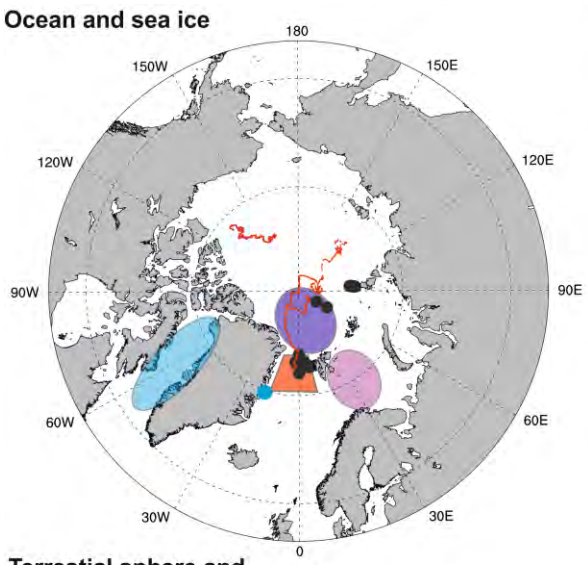
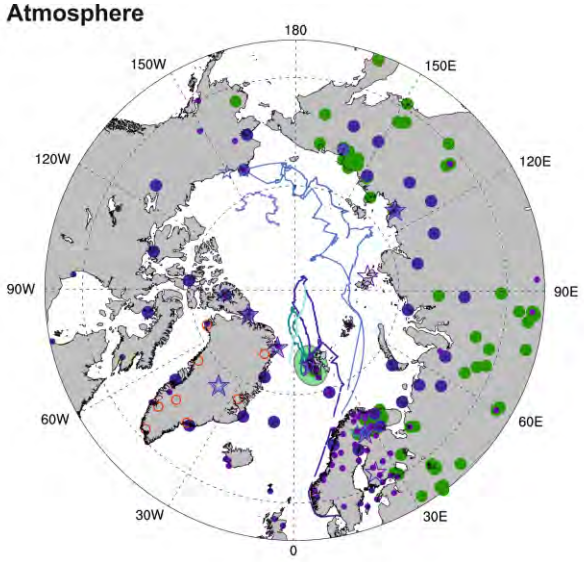
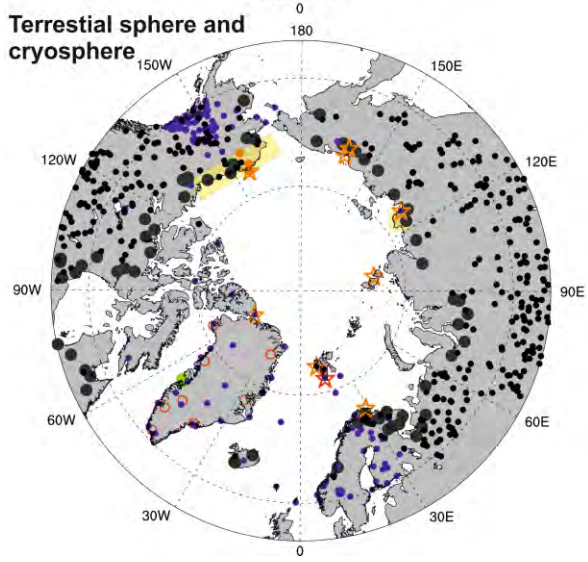
INTAROS Workpackage structure

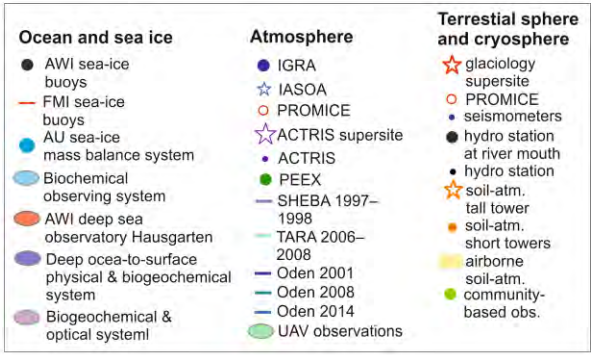


Overall objective of WP2









Assess, exploit, and standardize the existing Arctic observing systems

26 EU partners

Specific objectives of WP2

Task 1. Analyze strengths, weaknesses, and gaps of the existing observation networks and databases.

Task 2. Exploit selected datasets in order to increase the quality and number of data products

Task 3. Enhance standardization of data and metadata to ensure that best practices are followed, and integrate sparse in situ data into established networks, preparing their delivery to the iAOS

Task 4. Synthesis and recommendations.

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Task 4. Synthesis and recommendations.

Definitions: IN SITU OBSERVIG SYSTEM

It consists of a data collection component (infrastructure) and a data management component (e-infrastructure).

The data collection component is comprised of multiple sensors either belonging to a common long-term platform (such as tower, mooring, glider, buoy), which can be a single unity or a collection of units forming a network, or installed on a temporary platform (ship, aircraft, UAV, ocean/sea ice/land station).

The data management component includes hardware and software for data repository(s), the data processing, data discovery and visualization services. The management can be centralized in a single institution or distributed among several national institutions, which, in many cases, have agreed on common standards for the data and metadata formats, documentation and management.

Atmospheric observing systems: several of them are international networks, that follow standardized data managements.

Marine observing systems: are more diversified and fragmented, providing more types of data with various degree of standardization. They are usually identified on the basis of the utilized platforms (moorings, floats, gliders,…),

Definitions: IN SITU DATA COLLECTION

It is defined as "a collection of data, or measurement series, that have common characteristics in terms of quality, resolution, and coverage".

In most cases, the instrumentation used to collect the data determines the characteristics of the collection. The instruments applied to collect the data range from manual tools to fully automatized sensors. Hence, a data collection generally includes all the variables measured with a single instrument. In situ data collections also include derived data products which result from processing of individual measurements or composition of multiple measurements. In situ data collections can be surface-, subsurface-, and air-borne.

Different kind of in situ data collections:

1) data from established in situ networks, having regional (or Pan-Arctic) spatial coverage and variable temporal coverage,
2) data from single stations, having local areal coverage and variable temporal coverage,
3) data from field campaigns (land-, ship-, aircraft-, UAV-based measurements), with limited temporal coverage and from point to regional spatial coverage.

Method: Survey

Creation of **3 QUESTIONNAIRES**, to collect the info needed **TO ASSESS**:

A. The Arctic existing in situ observing systems
B. The Arctic in situ data collections: existing and exploited
C. The Arctic satellite products: existing and exploited

The questionnaires were web-based, open to all partners and collaborators through the INTAROS internal web page

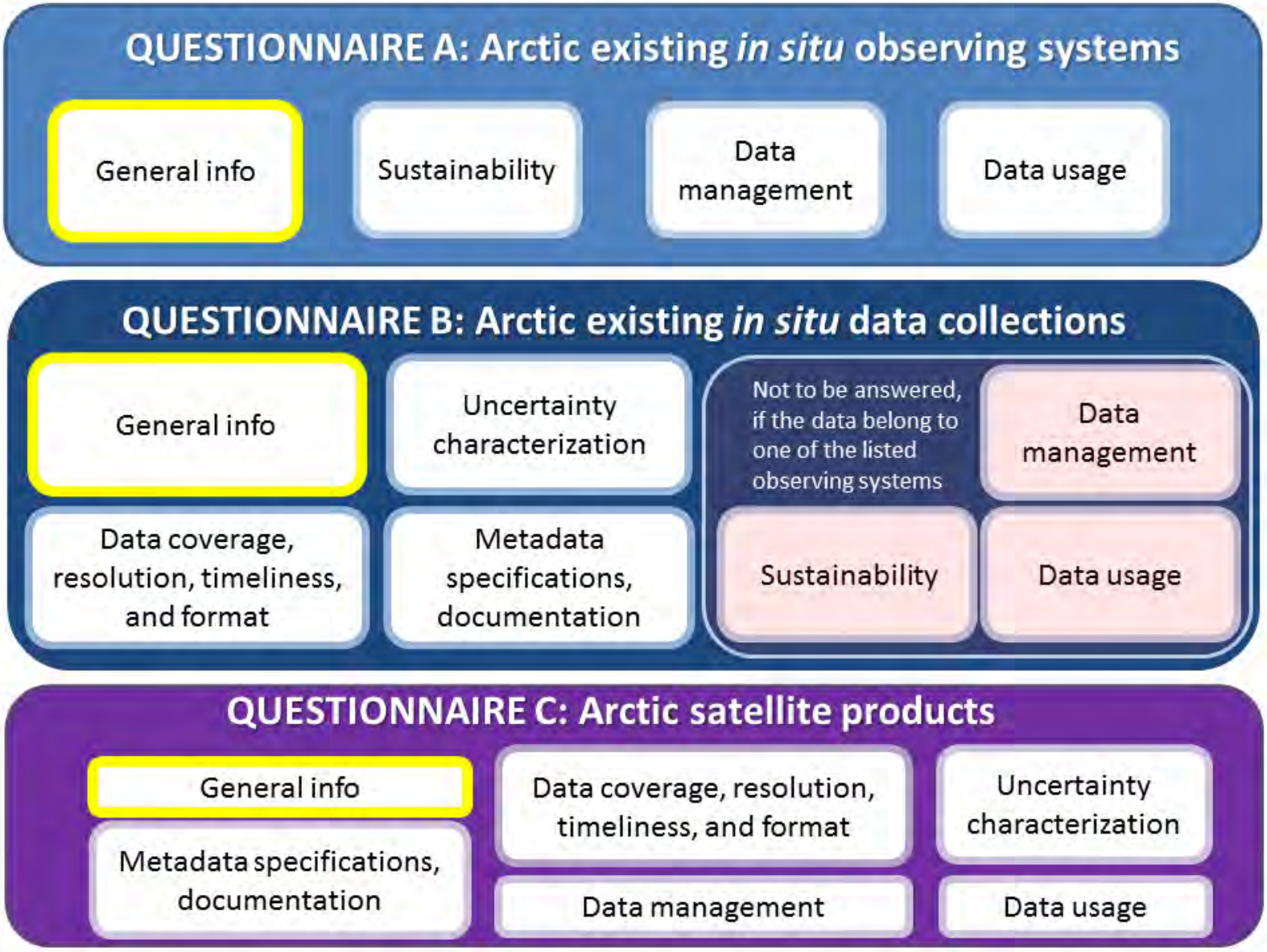
Foundation of the survey

This survey in large part builds upon similar efforts to assess:

- **climate data record maturity** (under the FP7 CORE-CLIMAX project, FP7 CORE-CLIMAX project. See CORE-CLIMAX Climate Data Record Assessment. Instruction Manual, CC/EUM/MAN/13/002, EUMETSAT, 2013),
- **measurement series maturity** (under the H2020 GAIA-CLIM project. See Thorne et al., Making better sense of the mosaic of environmental measurement networks: a system-of-systems approach and quantitative assessment, Geosci. Instrum. Method. Data Syst. Discuss., doi:10.5194/gi-2017-29, in review, 2017),
- **data management maturity** of the Polar observing systems (under the H2020 EU-PolarNet project. See Deliverable No. 3.1 - Survey of the existing Polar Research data systems and infrastructures, including their architectures, standard/good practice baselines, policies and scopes, 2016),

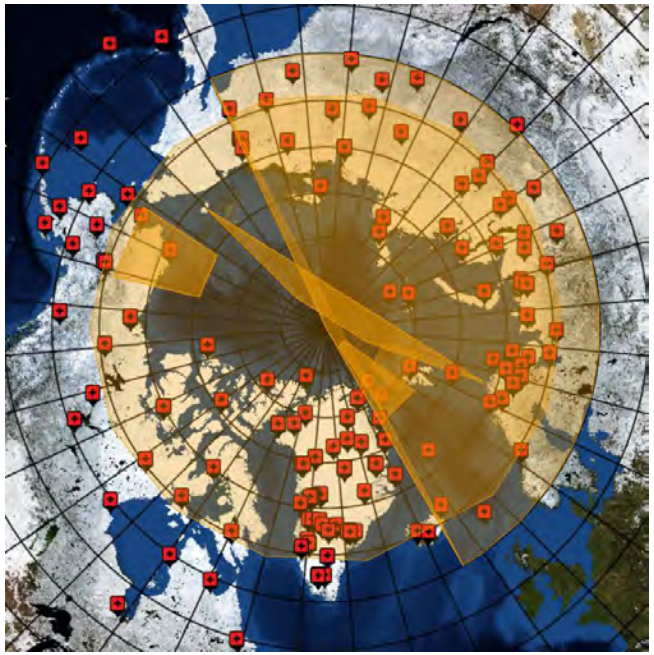
However, it addresses different data and domains, namely **Arctic in situ and satellite based observations from the ocean, atmospheric, terrestrial, and cryo- spheres.**

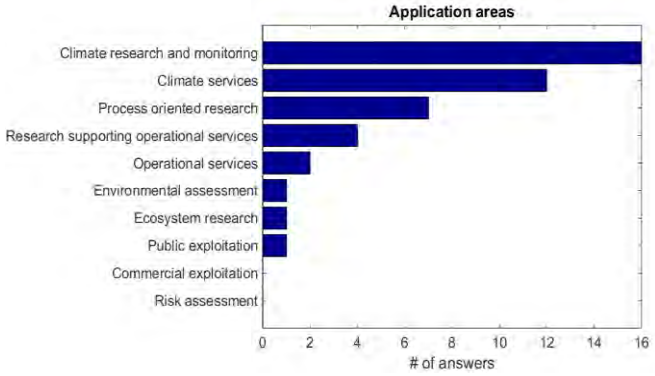
Content of the survey



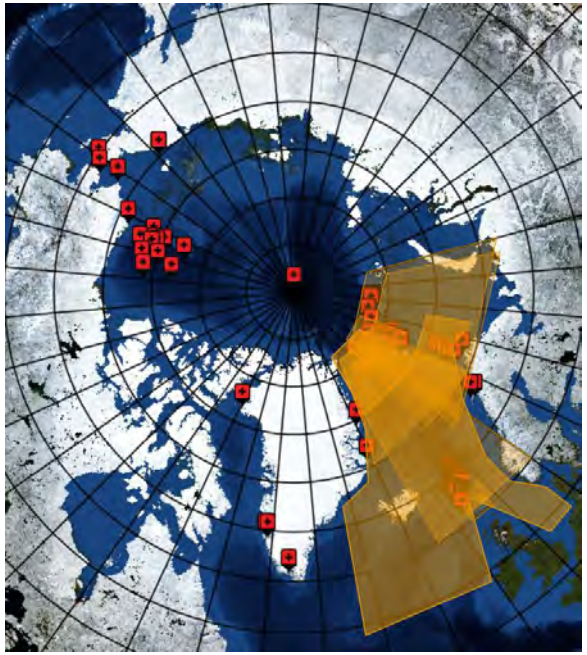
Overview of surveyed data:

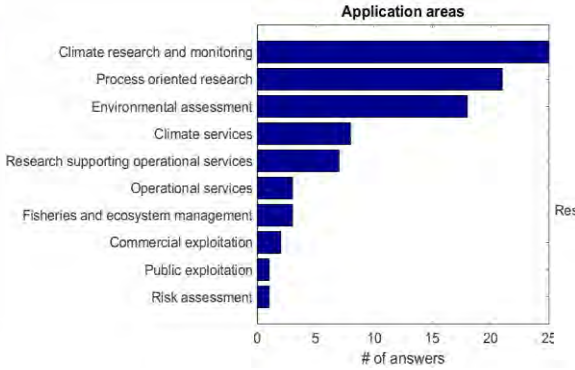
Atmosphere



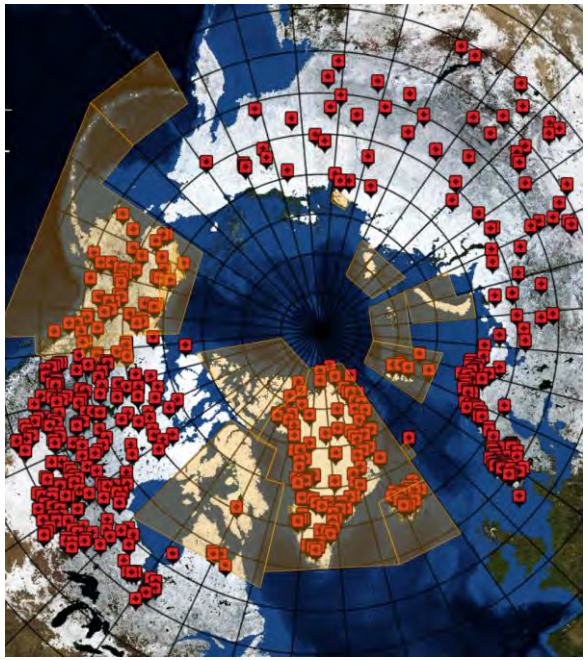


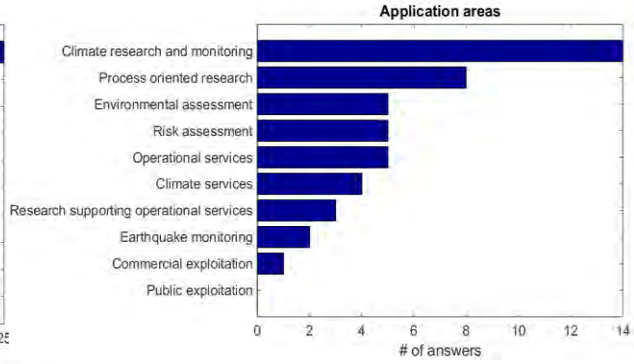
Ocean and sea ice



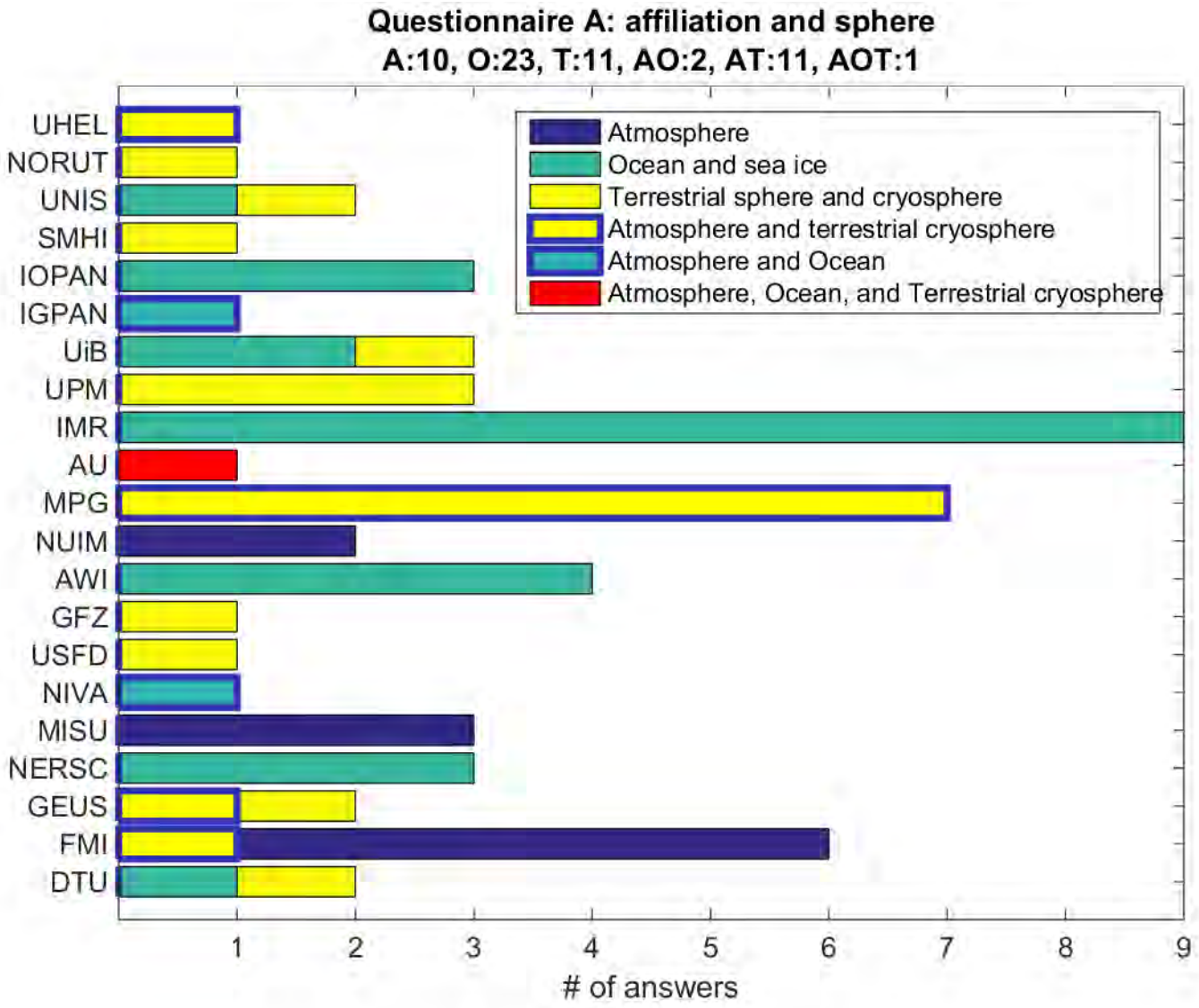


Land and terrestrial cryosphere

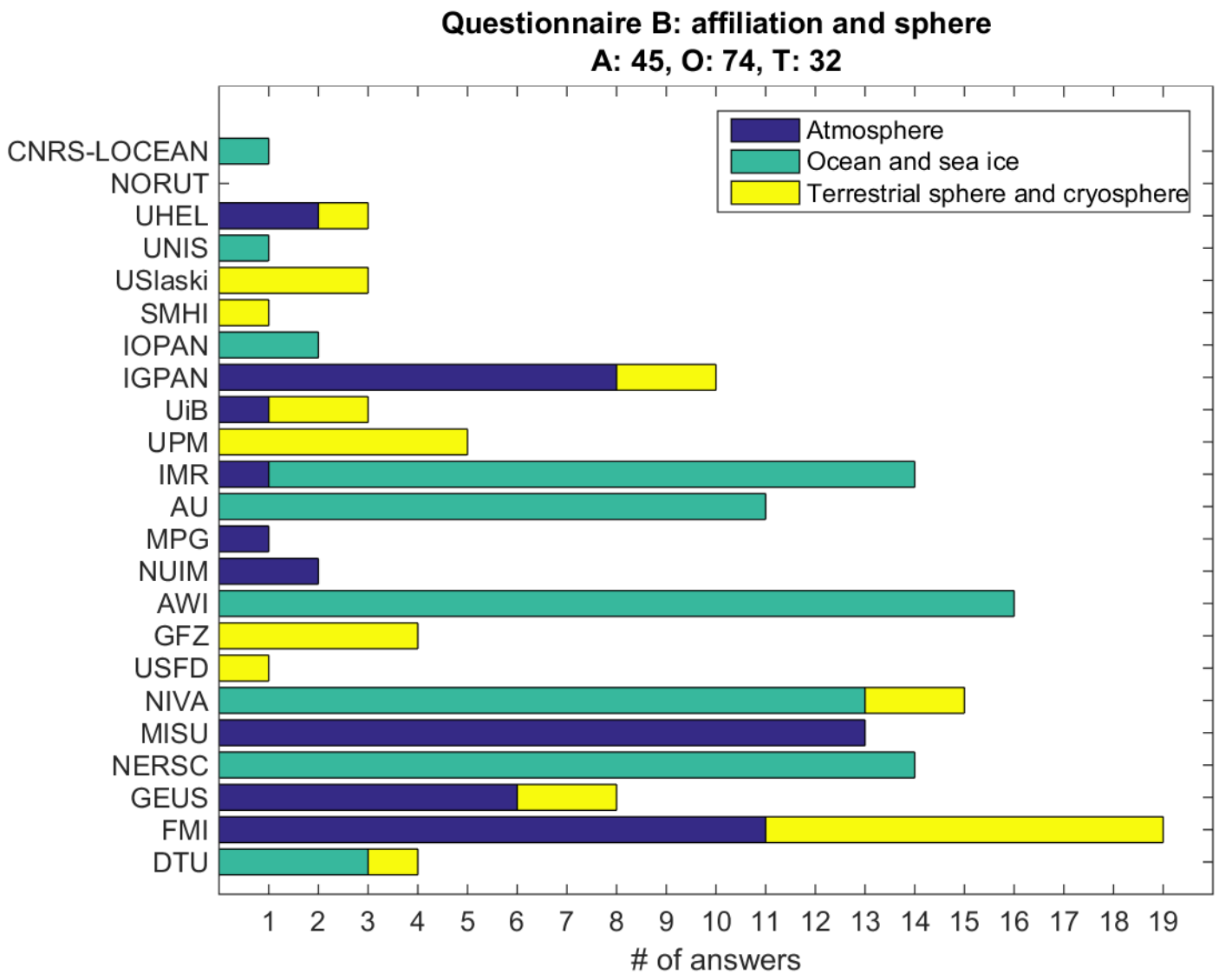




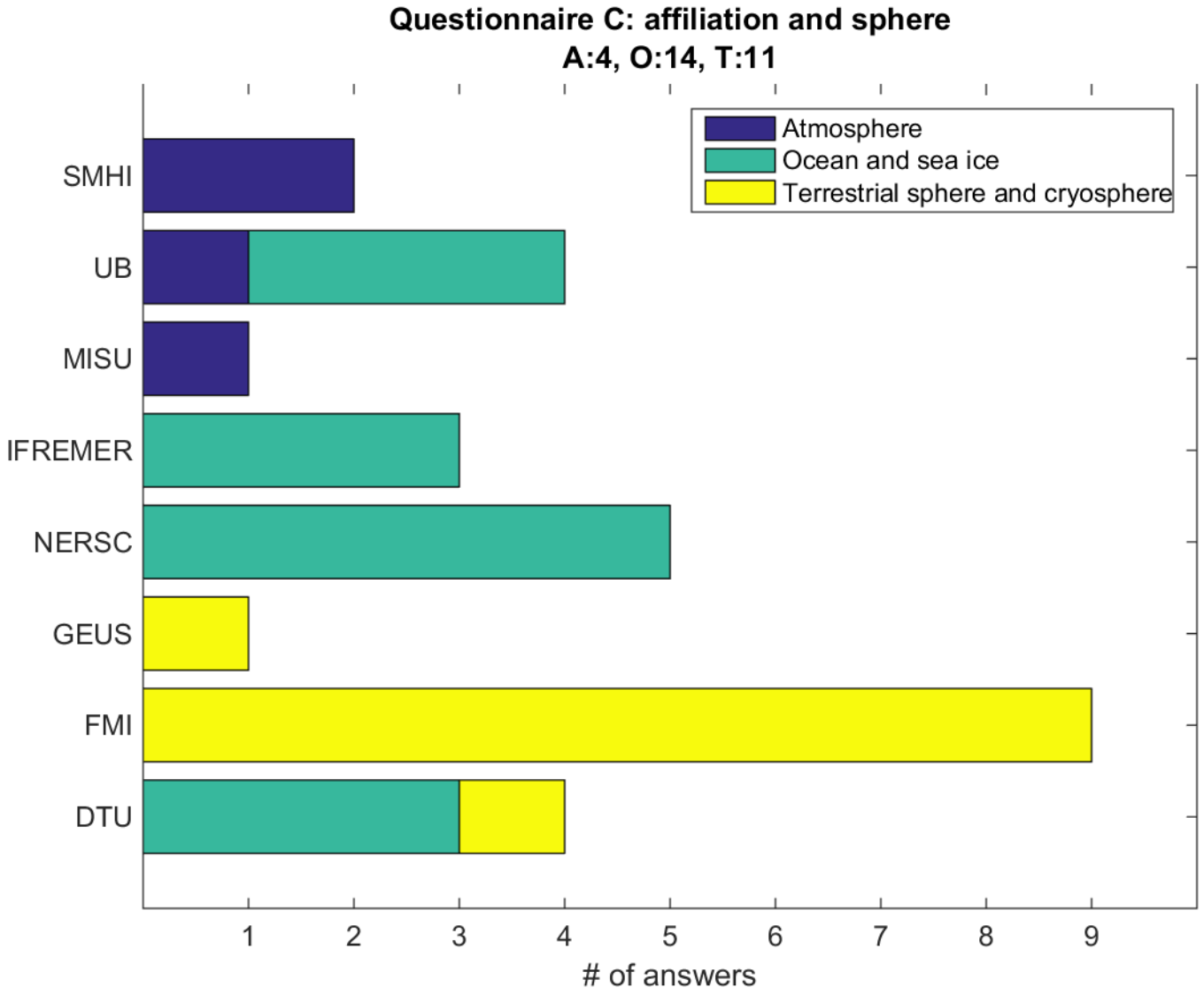
Survey overview. QA: 58 answers



Survey overview. QB: 149 answers



Survey overview. QC: 29 answers



Gap analysis: Data Specification vs Data Requirements

Requirements:

- For **in situ observing systems**, definition of requirements are stated for the spatial and temporal coverage of the systems and are discussed with respect to the scientific and/or monitoring purposes of the systems.
- For **satellite products and in situ data collections**, requirements are defined for data characteristics such as uncertainty and spatio-temporal coverage and resolution. They are taken from the WMO OSCAR database (https://www.wmo-sat.info/oscar/requirements). If OSCAR requirements are inapplicable (because not suitable for non-gridded data, or not tailored to the Arctic domain, or other reasons e.g. just missing), other requirements are described.
- For the sustainability of the observing systems, their data management, data uncertainty, metadata specifications and data documentations, the maturity gaps were defined with respect to the uppermost maturity level 6, in a scale from 1 to 6.

Results: Sustainability and data management

Atmosphere

SUSTAINABILITY

Observing system	Scientific and expert support	Funding support	Site representativeness (for land-based stations)
AC-AHC2 stable wa			
IMR-PINRO Ecosys			
IMR Barents Sea Wi			
Arctic Summer Clou			
Arctic Clouds during			
Norwegian Young S			
Sea State 2015 in situ			
Polarstern in situ fie			
Greenland Ecosyste			
PROMICE Automat			
Greenland Climate			
Radiosounding netw			
Global & regional G			
ICOS			
ACTRIS			
FMI Sodankylä (AW			
GRUAN			
Surface meteorological holdings (GOS)	3	5	1
Tower network for atmospheric trace gas mixing-ratio monitoring	3	3	3
NIVA Barents Sea FerryBox	6	4	
PEEX (Pan-Eurasian EXperiment)	3	5	3
Airborne observations of surface-atmosphere fluxes	4	4	5
Polish Polar Station Hornsund (WIGOS 01003)	4	5	3

DATA MANAGEMENT

Observing system	Data storage	Data access	User feedback	Updates to record	Version control	Long term data preservation
AC-AHC2 stable water isotope measurement stations	2	2	2	2	2	3
						4
						4
						4
						4
						4
						4
						4
						4
						5
						3
						5
						5
						5
						5
						4
						5
Surface meteorological holdings (GOS)	6	6	5	4	4	5
Tower network for atmospheric trace gas mixing-ratio monitoring	2 - 4	2	2	3	4	4
NIVA Barents Sea FerryBox	4	3	2	2	2	4
PEEX (Pan-Eurasian EXperiment)	2	2	2	2	2	4
Airborne observations of surface-atmosphere fluxes	2	2	2		2	4
Polish Polar Station Hornsund (WIGOS 01003)	4	3	2	2	2	4

CONCLUDING REMARKS

- There is a severe lack of all types of atmospheric observations over the Arctic Ocean. **Solution:** airborne dropsondes networks or satellite sensors: → development of retrieval methods for satellite atmospheric products should **target the special requirements that pertains to the Arctic**.

- Satellite retrievals rely on a priori information obtained trough models **Solution to improve them**: process studies → **more research-grade observations (icebreaker-based field campaigns)**.

Results: Sustainability and data management

Ocean and sea ice

Observation System	Platform	Sustainability			Data Management						Data repository
		support	ess*							ervation	
R/V Håkon Mosby	Vessels	5	5	N/A	3	4	2	3	2	3	NMDC
SAVN (Faerose National History Museum)	Community Based	missing			missing						
SIOS Airborne Infrastructure	Airborn Sensors	3	4	N/A	2	2	2	2	2	3	
UNIS ocean observing System	Fixed Moorings	4	4	N/A	2	2	2	2	2	3	

*(for terrestrial stations only)

CONCLUDING REMARKS:

- It is a major problem that in-situ observing systems **lack sustainability**.
- We recommend development of multi-disciplinary observatories using **well proven and robust instrumentation mounted in sea floor installations**, bottom anchored oceanographic moorings, and drifting ice-tethered platforms.
- Need to **develop and adapt technologies and sensors** to make biogeochemical and biological observations feasible.
- There are many gaps in the data coverage in the Arctic, but the **gaps in biogeochemical observations** are particularly important.
- In the Arctic there are **limiting factors in accessing data** in the same way as in other regions.

Results: Sustainability and data management

Land and terrestrial cryosphere

SUSTAINABILITY

Observing system			
Norwegian National Seismic Network (NNSN)	6	6	5
Greenland GPS Network (GNET)	5	5	5
Arctic-HYCOS river discharge (SMHI)	5	5	5

DATA MANAGEMENT

Observing system					Version control	Long term data preservation
Fluxnet (MPG, USI					3	4
PEEX (Pan-Eurasia					2	4
Sodankylä Observa					2	3
Airborne observati					2	4
PROMICE Automa					3	5
Fluctuations of Gla					5	5
Glacier Thickness I					5	5
Randolph Glacier I					2	4
Polish Polar Statio					5	5
Greenland Ice Shee					3	6
Norwegian National Seismic Network	6	6	2	1	1	5
Greenland GPS Network	5	5	5	5	5	5
Arctic-HYCOS river discharge	5	5	1	4	4	4

CONCLUDING REMARKS:

- **Land cover type, Greenhouse Gases, Soil carbon:** more measurements are needed.
- **Snow:** many variables that are still mostly manually measured should be automatized.
- **Greenland ice sheet:** the existing observational networks should include 1) Snow water equivalent, 2) High-precision elevation and position measurements of automatic stations, and 3) Liquid precipitation (rain).
- **Geological observations:** needs for: a) increasing the number of earthquakes observational sites, b) keeping analytical resources at a high level at the national and international centres, c) Adoption of real time data exchange on an international level.
- **River discharge observations**: improved timeliness of the data, improved metadata.

Available and upcoming reports

- **Reports on present observing capacities and gaps (Task 2.1)** **(31 May 2018)**
  - **D2.1** Ocean and sea ice
  - **D2.4** Atmosphere
  - **D2.7** Terrestrial sphere and cryosphere
- **Reports on exploitation of existing data (Task 2.2)** **(31 May 2018)**
  - **D2.2** Ocean and sea ice
  - **D2.5** Atmosphere
  - **D2.8** Terrestrial sphere and cryosphere
- **Observational gaps revealed by model sensitivity to observations (Task 2.1)**
  - **D2.12** Ocean and sea ice (UHAM), Atmosphere (FMI), Terrestrial sphere (MPG) **(30 November 2018)**
- **Catalogue of data products and services (Task 2.3)** **(30 November 2018)**

(Sparse data that trough INTAROS are made accessible via well served data repositories)

  - **D2.2** Ocean and sea ice
  - **D2.5** Atmosphere
  - **D2.8** Terrestrial sphere and cryosphere

Expansion of the assessment

PLAN:

- Inclusion of the Arctic data and observing systems that were not addressed in the firsts reports
- The responses to the survey shall be automatically stored in a web based database, openly accessible, were the results of the assessment are shown through simple plots/tables.
- Whenever new responses are received, the assessment should be updated

This tool will enable the demonstration of the benefits (in terms of gap closure) of the enhancements and expansions of the observing systems.

Resources: **ArcticMap** project funded by the Norwegian Directorate for Environment and Climate

Impacts so far:

- Same methodology applied to scientific and community based programs (**WP2 and WP4**): first time!
- **H2020 project ARICE** adopted the survey to monitor the observing systems based on research vessels
- **AOS and INTAROS** had a coordinated effort to evaluate the observational needs In the Arctic
- **AGU**: dedicated INTAROS session with AOS contributors
- **EGU**: dedicated INTAROS session
- **SAON and AMAP**: they support the expansion of the assessment
- **Ministries** (from Denmark and Norway) have given positive feedback to the INTAROS assessment

INTAROS

Thank you for your attention